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(54) ELECTROSTATIC IMAGING DEVICE AND PROCESS USING SAME

(71) We, AGFA-GEVAERT, a naamloze vannootschap organised under the laws of Belgium, of Septstraat 27, B 2510 Mortsel, Belgium, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the formation of electrostatic charge patterns upon a substrate and devices for producing such patterns.

From German Patent 1,497,093 (Siemens A. G.) an imaging technique is known in which a photocathode is used to produce an electrostatic charge pattern on a non-photosensitive insulating material. In this technique an air-tight chamber is filled with an ionizable gas e.g. a mixture of argon and monobromotrifluoromethane (1:5) and is provided with a photocathode and an anode, the latter being covered with an insulating recording material e.g. insulating resin sheet. Simultaneously with an object-wise modulated X-ray exposure a direct current potential is applied across the electrodes so that the photoelectrons, which are ejected imagewise from the photocathode, are strongly multiplied by an avalanching process in the ionizoble gas. The electrons are collected on the insulating material in an image pattern corresponding to the intensity of the imaging radiation absorbed in the photocathode.

The distance in the gas medium to be travelled by the photo-electrons determines the amount of electrons produced in the avalanche and collected on the insulating material. The increase of the distance, however, also increases the sideways spreading of the electrons and results in a considerable reduction in image sharpness.

In one embodiment of said German Patent Specification in order to prevent reduction in image sharpness by electron divergence a screen with minute holes is provided on an heavy metal electrode emitting photo electrons. The minute holes of the screen, the diameter of which may be e.g. 0.2 mm and the depth e.g. 0.8 mm can be made in a plastic material or metal screen. By means of a screen having the above hole dimensions, the photo-electrons which, when liberated by X-rays, are emitted in all directions from the heavy metal layer are directed in such a way that the ones diverging by more than 15° from the perpendicular on the plane of the electrode become absorbed. On one side of the screen the hole sides are connected with the electrode, on the other side the holes are covered with a thin, e.g. 0.01 mm thick aluminium foil. In order to oppose little resistance to the electrons, the screen interstices may be filled with gas consisting of light weight molecules e.g. air.

According to the above embodiment the aluminium foil covering the openings of the screen serves as an electrode and the electrons emitted therefrom interact with the ionizable gas particles and effect the avalanching process. Operating that way, the sideways spread electrons present in the electron-multiplying avalanche are not removed by the above defined screen and still impair the image sharpness. So, the above described embodiment, which is interesting for eliminating electrons that are emitted obliquely from the photocathode does not remedy image unsharpness resulting from the sideways electron spreading in the electron multiplicating avalanche in the ionizable gas medium.

The present invention aims to provide means and methods which can bring about improved sharpness in the image formation in an envelope containing an ionizable gas medium.

According to the present invention, a method of recording in terms of an electrostatic charge pattern, a charged particle emission pattern representing information to be recorded and generated in the interior of an envelope which contains an ionizable gas medium e.g. low pressure gas medium and comprises an insulating target towards which the charged particles e.g. electrons of the charged particle emission pattern are projected, is characterized in that in said envelope between a means producing the

charged particle emission pattern and the insulating target there is interposed a device containing a plurality of narrow passages for intercepting sideways spread of the charged particles, the walls thereof being not substantially secondary electron emissive, and the input-openings of which are directed to or contact the means producing the charged particle emission pattern and its windowless output-openings are directed towards the insulating target which is demountable or removable from the envelope and said device.

The information-wise distributed pattern of emitted charged particles is herein referred to as "the charged particle emission pattern" or "image".

The charged particle emission image may be produced by making use of a photocathode or photocathode system by information-wise exposing such cathode to a pattern of radiant energy representing the information to be recorded thereby causing the emission of photoelectrons in a pattern corresponding with the pattern of radiant energy.

The invention also provides an imaging device for forming an electrostatic charge pattern wherein said device contains in a gas-tightly closed envelope a cathode for generating an electron emission pattern and an ionizable gas and between said cathode and an insulating charge receiving target a device comprising a plurality of narrow passages for intercepting sideways spread of charged particles emitted by the cathode, the walls of the passages being not substantially secondary electron emissive, and the input openings of which are directed to or contact the cathode and the windowless output-openings of which are directed towards the insulating target which is demountable or removable from the envelope and said device.

In general it is envisaged that the electrostatic charge pattern is built up by electrons, however, the wording "charged particle emission image" includes here likewise an electrostatic charge pattern which is built up by positive ions resulting e.g. from an electrical discharge in the gas present in the envelope.

Several embodiments in which the device containing a plurality of narrow passages i.e. "microchannels" is used for improving the image sharpness are illustrated in the accompanying drawings, in which:

Fig. 1 is a schematic sectional view of a recording system structure including a photocathode, a microchannel device and a removable insulating target sheet.

Figs. 2 and 3 are cross-sectional representations of alternative imaging structures containing a photocathode, a microchannel device and a removable insulating target sheet.

Fig. 4 is a cross-sectional representation of a special embodiment of the present invention, in which embodiment the microchannel device and photocathode are the same structural part of an imaging appliance according to the present invention.

It should be understood that in these figures some dimensions of the layers, photocathode, microchannel plate, insulating target sheet, etc., have been greatly exaggerated to show the details of the construction. No inferences should be drawn as to the relative dimensions of the layers or spacing separating the various elemental parts of the imaging apparatus.

Referring to Fig. 1 the imaging apparatus comprises a photocathode 1, a microchannel plate 2 the input openings of which are in contact with the photocathode 1 and the output-openings of which are directed to a removable insulating charge receiving sheet 3, e.g. insulating resin film coated at the rear side with a transparent conductive layer 4. The microchannel plate 2 is made of electrically insulating material e.g. an insulating resin or glass and is in direct contact with the photocathode 1. The insulating charge receiving sheet 3 is enclosed in an envelope or cassette 5 from which it can be removed. The conductive layer 4 makes intimate contact with a conductive layer or plate 6 that is connected to the plus pole of a DC-voltage source 7, the negative pole of that voltage source being connected to a conductive backing layer 8 of the photocathode 1. The cassette 5 contains electrically insulating coatings 9 on its inner walls. The demountable cassette 5 can be evacuated and provided with ionizable gas as desired pressure through the pipe fitting 10. The compressable sealing strips 11 e.g. made of polytetrafluorethylene provide an air-tight assembly of the two cassette parts.

The cassette 5 is filled with an ionizable gas or gas mixture e.g. (a) rare gas(es) in admixture with a discharge quenching substance e.g. ethanol as described e.g. in the German Patent 1,497,093 as mentioned above. The filling gas is advantageously kept under a pressure of 0.1 to 10 Torr preferably 1 to 5 Torr above atmospheric pressure. A useful gas mixture consists e.g. of argon and monobromotrifluoromethane (CF_3Br) in the weight ratio 1:5. When using the above fluoromethane a separate quenching additive is not required. The applied D.C. voltage is preferably not more than 5% above the breakdown voltage of the gas.

The ionizable gas or gas mixture has not necessarily to be used at atmospheric pressure or reduced pressure. A xenon gas containing visible-light-emitting imaging device operating at pressures above atmospheric pressure e.g. 2 atmospheres has been described by A. Lansiart et al, in Nuclear Instruments and methods 44 (1966) 45—54- North-Holland Publishing Co. An electrostatic

imaging device operating at a pressure above atmospheric pressure with an ionizable gas having an atomic number at least equal to 36 e.g. xenon has been described in the Belgian Patent 792,334 (Xomes Inc.).

The height of the microchannel plate 2 and the cross-section of each individual microchannel determine the image sharpness. A suitable cross-section diameter is e.g. from 10 to 200 microns. The ratio of cross-section diameter to the height of the individual microchannels is preferably at least 1:4.

As will be noted from the drawing, the charge receiving sheet 3 is held spaced from the microchannel plate 2.

The distance between the windowless output opening ends of the microchannel plate and of the insulating charge receiving sheet 3 is preferably not larger than 1.5 mm.

According to a variant embodiment the windowless opening ends of the microchannel plate make contact with the insulating sheet, whereby that sheet is kept perfectly flat, and in case of pressure contact with said windowless opening ends a very homogeneous electrical contact between the electrically conductive layer 4 and the electrically conductive layer or plate 6 is obtained.

The total potential difference between the photocathode and the rear side of the insulating target material forms an accelerating field acting upon the electrons and determines together with the kind of ionizable gas and its pressure the degree of the electron avalanching effect.

According to a special embodiment the microchannel plate is an assembly of electrically insulating resin or glass sheets or conductive sheets e.g. metal sheets whether or not coated with an insulating material e.g. insulating resin. Said sheets are corrugated in a direction parallel to the desired path of electron flow, so that said corrugations cooperate to provide parallel channels or conduits for said electrons. The manufacture of such channel plates but having secondary-emissive characteristics has been described in the United Kingdom Patent 954,248 (Bendix Corp.). Other techniques for producing microchannel plates are described in United Kingdom Patents 1,064,072 and 1,064,075 (Mullard Ltd.). For the purpose of the embodiment discussed in connection with Fig. 1 the materials of the plate are chosen in such a way that the secondary emission on the microchannel walls does not or does not substantially occur under the conditions of voltage, gas composition and gas pressure applied in the imaging apparatus of Fig. 1. Indeed, secondary emission resulting from so-called "ionic feed-back" (see IEEE Transactions on Nuclear Science Vol. NS-13 June 1966, pages 88—99 has to be avoided since at a particular gas pressure normally above 10^{-4} Torr (see Advances in Electronics and Electron Physics Vol. 28 (1969) pages 499—506) a self-sustaining discharge is obtained in the gas-medium which discharge degrades the electrostatic charge image on the insulating target. The ionic feedback is a phenomenon which arises when ions produced at the output end of the channels are accelerated back down the channels and set free secondary electrons by striking the secondary emissive inner walls at the input ends of the channels. The electrons density may be increased thereby in such a degree that a self-sustaining discharge occurs, which has to be avoided.

The exposure of the photocathode e.g. with information-wise modulated X-rays may proceed from the rear side (i.e. the side adjacent to the microchannels) or front side e.g. proceeds as described in United States Patents 2,221,776 (Chester F. Carlson) and 3,526,767 (Walter Roth and Alex F. Jvirblis) or as in published German Patent Application 2,231,954 (Diagnostic Instruments).

Referring to Fig. 2 the imaging apparatus comprises a photocathode 20, a microchannel plate 21 the openings of which are directed to an insulating charge receiving sheet 22 e.g. insulating resin film coated at the rear side with a transparent conductive layer 23. The michrochannel plate 21 is in close proximity e.g. its input-openings are at a distance less than 0.5 mm or in contact (the contact embodiment is shown in Fig. 2) with the photocathode 20. The input-openings of the microchannel plate make no electrically conductive contact with the photocathode material. Therefore, when using as illustrated in the present Fig. 2 electrically conductive microchannels e.g. composed of metal sheets e.g. aluminium sheets which are corrugated in a direction parallel to the desired path of electron flow, the input opening ends of the channels have been coated with an electrically insulating material 24 e.g. applied by dipping them in an insulating hardenable resin, by vacuum coating with an insulating substance or by oxidation of the metal e.g. aluminium, obtaining that way an electrically insulating oxide layer preventing direct electric contact with the photocathode.

The output-opening ends of the microchannel plate 21 are electrically connected through a variable resistor 25 with the plus pole of a DC-voltage source V1, the minus pole is connected to the electrically conductive support 26 of the photocathode 20. The conductive layer or rear side 23 of the insulating target sheet 22 is electrically connected through the conductive support 27 with the plus pole of the voltage source V_2.

The ratio of cross-section diameter to the height of the individual microchannels is preferably at least 1:4. By operating with such a microchannel plate of which the inner walls, are electrically conductive at least over

a part of the length of the channels, electrons that deviate for more than 15° from the perpendicular between the photocathode 20 and charge receiving insulating sheet 22 are carried off to the positive pole of the voltage source V1. The variable resistor 25 determines the voltage difference and the rate of the carrying off of the sideways spread electrons.

The distance between the output-opening ends of the microchannel plate 21 and of the insulating charge receiving sheet 22 is preferably not larger than 1.5 mm in order to obtain good image-sbarpness.

In Fig. 2 the envelope walls that are provided with a pipe fitting as illustrated in Fig. 1 are not shown.

According to another embodiment illustrated in Fig. 3 the imaging apparatus comprises a photocathode 30 and a microchannel plate 31 of electrically insulating material e.g. a microchannel plate 31 formed of an assembly of parallel glass tubes manufactured e.g. according to a technique described in the United Kingdom Patent 1,064,072 as mentioned above or a technique described by G. Eschard and R. Polaert in Philips Technisch Tijdschrift, *30* (1969) pages 257—261. The inner walls of the glass tubes 32 are provided with a conductive material 33 e.g. metal layer applied by vacuum coating but a part at the input-opening end of the tubes is left free from such conductive coating or that coating is removed in that part e.g. by etching. The output openings of the microchannel plate 30 are directed to an insulating charge receiving sheet 34 e.g. insulating resin film coated at the rear side with a transparent conductive layer 37. The microchannel plate 31 is with its insulating input opening ends in contact with the photocathode 30.

The output-opening ends of the microchannel plate 31 are electrically connected through a variable resistor 35 with the plus pole of a DC-voltage source V1, the minus pole being connected to the electrically conductive support 36 of the photocathode 30. The conductive layer or rear side of the insulating target sheet 34 is electrically connected through the conductive support 38 with the plus pole of the voltage source V2.

The apparatus illustrated in Fig. 3 is operated in the way as described in connection with Fig. 2. The envelope walls with pipe fitting as illustrated in Fig. 1 are not shown.

For the purpose of the embodiments discussed in connection with Fig. 2 and Fig. 3 the inner walls of the microchannels are for the major part of their length (preferably for at least 50%) electrically conductive so that the conductive wall material or conductive inner coatings offer an electrical resistance preferably less than 10^{6} Ohm per sq. cm between the beginning of the conductive material near the input-openings and the output-openings of the channel plate.

According to a special embodiment illustrated in Fig. 4 the means producing the electron discharge pattern and the solid state device comprising a plurality of narrow passages are one and the same part of the electrostatic imaging device.

In that embodiment the photocathode contains a plurality of lamellae that may be corrugated or grooved in a direction parallel to that of the desired path of electrons through the device, so that said corrugations or grooves co-operate to provide said parallel channels or conduits. According to another embodiment the photoelectrons emitting device contains hollow fibres (narrow tubes) of which at least a part of the wall material has photoelectron emitting properties when struck with penetrating radiation e.g. X-rays, γ- and β-rays, fast electrons or neutrons.

It has been established theoretically and experimentally (see e.g. A. H. Compton and S. K. Allison, "X-rays in Theory and Experiment", N.Y., (1935) 564—582). that the major part of photo-electrons are set-free in a direction perpendicular to the propagation direction of the X-rays. In comparison with a flat photo-electrode which is struck by X-rays at an angle of about 90° the photo-electrode in lamellar or narrow tube form presents a plurality of small walls or edges substantially parallel with the X-rays so that the X-rays are absorbed therein over a much longer path and consequently photoelectrons are emitted at a larger amount. The electrons collide with the gas molecules present in the interspaces between the lamellae or inner spaces of the narrow tubes and set free a further amount of electrons by ionisation. By using for the wall material of the lamellae or tubes an element or mixture or compound containing elements with high atomic number (Z equal to or larger than 50, preferably larger than 70) a relatively high absorption of X-rays is obtained.

Since the electrons for the major part are emitted in a direction perpendicular to the lamellae or tube walls they have to be deflected in a direction being parallel to the lamella or tube walls. This deflection is produced by an electric field that is substantially parallel to said walls. The distribution and cross-sections of the interspace of channels between the lamellae or of the tubes are such that the resolution and photoelectron emission characteristic of any unit area of the lamella or tube assembly is sufficiently similar to any other unit area for the imaging purposes envisaged. The length to width ratio of the channel or vertical plate photocathode is preferably at least 10.

The lamellae may be corrugated so that

tubelike interspaces are formed by assembling corrugated sheets or corrugated sheets with flat sheets as described in United Kingdom Patent 954,248 as mentioned above. The sheets may be made of pure metal or glass containing high atomic number (Z) elements e.g. lead or bismuth. Another way of producing microchannels with grooved material is described in United Kingdom Patent 1,064,075 as mentioned above. The height of the passages formed by the lamellae or tubes used is e.g. 0.01 to 2 mm. The cross-section of the space between the walls of the lamellae or tubes is e.g. 10 to 200 microns.

In Fig. 4 the imaging apparatus comprises a photocathode 1 composed of a plurality of lamellae or narrow tubes of a material containing one or more high atomic number ($Z>50$) elements. Optionally a light atomic number ($Z<50$) material covers the inner walls in order to slow down the velocity of the photoelectrons in the direction perpendicular to the lamella or tube walls. With the DC-voltage source 7 a potential difference is applied between plate 12 that optionally has photoelectron emissive properties and a conductive anode 6 which contacts the electrically conductive rear side coating 4 of an electrically insulating charge receiving sheet 3. The insulating sheet 3 is enclosed in a cassette 5 from which it can be removed. The cassette 5 contains electrically insulating coatings 9 on its inner walls. The demountable cassette 5 can be evacuated and provided with ionizable gas through the pipe fitting 10. The compressable sealing strips 11 are made e.g. of polytetrafluoroethylene.

The photocathode has to be resistive to atmospheric contact, in other words it should not be effected in its photoelectron emissive power by e.g. oxygen or water vapour that may enter the cassette during its demounting and the removal and replacement of the insulating film. Otherwise the opening or demounting of the cassette has to be carried out under gas conditions that do not affect the photocathode.

Photocathodes which are sensitive to atmospheric conditions are therefore only applied in high vacuum (less than 10^{-3} Torr) or in inert gas conditions. An example of the use of such photocathodes in an X-ray image amplifier tube has been given in The Physical Basis of Electronics of J. G. R. Van Dyck-Centrex Publishing Company—Eindhoven (1964) page 209. In said tube the photocathode system consists of a photocathode which is sensitive to light emitted by a fluorescent layer that fluoresces when struck by X-rays and that receives photoelectrons emitted by a lead layer applied to an aluminium support carrying the fluorescent layer.

The lead or uranium X-ray sensitive photocathodes that may be used as illustrated with the Figs. 1 to 4 are not sensitive to the gases of the atmosphere so that no special precautions, e.g. the use of a lock-chamber for removing the insulating film need be taken.

It is clear, that when the imaging process proceeds under conditions in which photocathode damage is prevented the material of the photocathode may be any type of photoelectron emitting substance or composition known in the art. For example, it may be directly sensitive to X-rays, visible light and/or ultra-violet or infra-red radiation.

A non-limitative survey of photocathode material is given by H. Bruining in his book Physics and Application of Secondary Electron Emission—Pergamon Press Ltd.—London (1954).

The invention is not limited by the type of development of the electrostatic charge pattern on the insulating target that before its development is removed from the electrostatic imaging chamber.

The development of the electrostatic charge image proceeds preferably with finely divided electrostatically attractable material that is preferably sufficiently nontransparent for visible light, but may proceed by surface deformation which is a technique known as "Thermoplastic Recording" see e.g. Journal of the SMPTE, Vol. 74, p. 666—668.

According to a common technique the development proceeds by dusting the insulating film or film layer bearing the electrostatic image with finely divided solid particles that are image-wise electrostatically attracted or repulsed so that a power image in conformity with the charge density is obtained.

The expression "powder" denotes here any solid material e.g. finely divided solid material in liquid or gaseous medium, and that can form a visible image in conformity with an electrostatic charge image.

Well-established methods of dry development of the electrostatic latent image include cascade, powder-cloud (aerosol), magnetic brush, and fur-brush development. These are all based on the presentation of dry toner to the surface bearing the electrostatic image where coulomb-forces attract or repulse the toner so that, depending upon electric field configuration, it settles down in the electrostatically charged or uncharged areas. The toner itself preferably has a charge applied by triboelectrcity.

The present invention, however, is not restricted to the use of dry toner. Indeed, it is likewise possible to apply a liquid development process (electrophoretic development) according to which dispersed particles are deposited by electrophoresis from a liquid medium.

The dispersed toner particles may be any powder forming a suspension in an insulating liquid. The particles acquire a negative or positive charge when in contact with the liquid due to the zeta potential built up with

respect to the liquid phase. The outstanding advantages of these liquid developers are almost unipolarity of the dispersed particles and their appropriateness to very high resolution work when colloidal suspensions are applied.

Suitable electrophoretic developers are described e.g. in United States Patent 2,907,674 (Kenneth Archibald Metcalfe and Robert John Wright) and United Kingdom Patent 1,151,141 (Gevaert-Agfa N.V.).

The electrostatic image can likewise be developed according to the principles of "wetting development" e.g. as described in United Kingdom Patents 987,766 (Agfa A.G.), and 1,020,505 and 1,020,503 (Gevaert Photo–Producten N.V.).

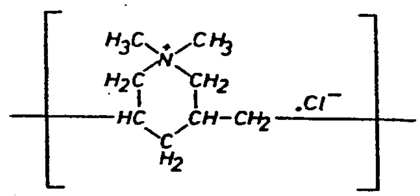
According to a particular embodiment the charge pattern is developed in direct relation to the quantity of charge, instead of to the gradient of charge (fringe effect development). Therefor the developer material is applied while a closely spaced conductor is situated parallel to the insulating charge receiving member. (See for such type of development e.g. PS&E, Vol. 5, 1961, page 138).

According to another embodiment a transferable toner is used and the powder deposit forming the developed image is transferred from the support containing the electrostatic charge image to e.g. a flexible support e.g. transparent film or paper support. In the latter case, any known process for transferring powder image-wise from one support to another can be used; such powder transfer processes are well known in the art of electrophotography. If an electrostatically attractable powder is used, the powder image can be transferred by electrostatic attraction, e.g., according to the method disclosed in United Kingdom Patent 658,699 (Batelle Memorial Inst.). Further details are contained in United States Patents 3,384,488 (Vsevolod Tulagin and Leonard M. Carreira) and 3,565,614 (Leonard M. Carreira, Ira S. Stein and Vsevolod Tulagin). If a powder with ferromagnetic properties is used for developing the electrostatic latent image, the powder can be transferred by magnetic attraction. The transfer can like-wise be carried out by adhesive pick off with an adhesive tape or sheet e.g. SCOTCH (Trade Mark) brand cellophane tape.

The final powder image is e.g. fixed by heat or solvent treatment.

The charge pattern may be formed on any type of electrographic recording material. For example the recording material may be a recording web consisting of an insulating coating of plastic on a paper base having sufficient conductivity to allow electric charge to flow from the backing electrode to the paper-plastic interface. For a particular electrographic paper reference is made to United States Patent 3,620,831 (Floyd T. Could).

As substances suited for enhancing the conductivity of the rear side of a transparent resin sheet are particularly mentioned antistatic agents preferably antistatic agents of the polyonic type, e.g. Calgon Conductive Polymer 261 (trade mark of Calgon Corporation, Inc. Pittsburgh, Pa., U.S.A.) for a solution containing 39.1% by weight of active conductive solids, which contain a conductive polymer having recurring units of the following type:



and vapour deposited films of chromium or nickel-chromium about 3.5 micrometer thick and that are about 65 to 70% transparent in the visible range.

Cuprous iodide conducting films can be made by vacuum depositing copper on a relatively thick resin base and then treated with iodine vapour under controlled conditions (see J. Electrochem. Soc., 110—119, Feb. 1963). Such films are over 90% transparent and have surface resistivitites as low as 1500 ohms per square. The conducting film is preferably over-coated with a relatively thin insulating layer as described e.g. in the Journal of the SMPTE, Vol. 74, p. 667.

WHAT WE CLAIM IS:—

1. A method of recording with an electrostatic imaging device in terms of an electrostatic charge pattern, a charged particle emission pattern representing information to be recorded and generated in the interior of an envelope which contains an ionizable gas medium and comprises an insulating target towards which charged particles are projected, characterized in that in said envelope between a means producing the charged particle emission pattern and the insulating target there is interposed a device comprising a plurality of narrow passages for intercepting sideways spread of the charged particles, the walls thereof being not substantially secondary electron emissive and the input openings of which are directed to or contact the means producing the charged particle emission pattern and its windowless output-openings are directed towards the insulating target which is demountable or removable from the envelope and said device.

2. A method according to claim 1, wherein said gas medium contains an ionizable gas at a pressure below atmospheric pressure.

3. A method according to claim 1, wherein said gas medium contains an ionizable gas

at atmospheric pressure or a pressure above atmospheric pressure.

4. A method according to claim 3, wherein the charged particle emission pattern is an electron pattern that at least is partly built up by photoelectrons generated by information-wise exposing a photocathode to a pattern of radiant energy representing the information to be recorded.

5. A method according to claim 4, wherein said electron image is composed of secondary electrons and/or ions produced in an ionizable gas or gas mixture in response to photoelectrons generated by information-wise exposing a photocathode to a pattern of radiant energy representing the information to be recorded.

6. A method according to claaim 4, wherein an electromagnetic radiation pattern is recorded in the form of an electrostatic charge pattern and wherein a photocathode is information-wise irradiated and thereby information-wise produced photoelectrons from the photocathode are introduced into a device including a plurality of electrically insulating narrow passages that are arranged in substantially parallel relationship to each other in an ionizable gas medium being under reduced pressure in which the photo-electrons are in an electric field and information-wise produce an electron avalanche by their interaction with the gas molecules of the medium and wherein the electrons are ejected from the windowless openings of said passages onto the insulating target material whereon they form an electrostatic charge pattern inside the reduced pressure medium.

7. A method according to claim 6, wherein between a conductive backing of the photocathode and a conductive backing applied on or contacting the insulating target material a DC-voltage source is connected with the negative pole to the conductive backing of the photocathode and with the positive pole to the conductive backing of the insulating target material.

8. A method according to claim 6, wherein said device is made of glass tubes having a diameter in the range of 10 to 200 microns.

9. A method for recording according to claim 1, wherein an electrostatic radiation pattern is recorded in the form of an electrostatic charge pattern and wherein a photocathode is information-wise irradiated and thereby information-wise produced photoelectrons from the photocathode are introduced into a device including a plurality of narrow passages that are electrically conductive but at the input end are coated with an electrically insulating material that does not block the input-openings, said narrow passages being arranged in substantially parallel relationship to each other in an ionizable gas medium under reduced pressure in which the photoelectrons in an electric field informationwise produce an electron avalanche by their interaction with the gas molecules of the medium and wherein the electrons contacting the conductive part of the narrow passages are at least partially carried off and the electrons leaving the windowless output-openings are collected informationwise onto the insulating target material whereon they form an electrostatic charge pattern inside the reduced pressure medium.

10. A method according to claim 9, wherein between a conductive backing of the photocathode and a conductive backing applied on or contacting the insulating target material a DC-voltage source is connected with the negative pole to the conductive backing of the photocathode and with the positive pole to the conductive backing of the insulating target material.

11. A method according to claim 9, wherein between the conductive backing of the photocathode and the conductive part of the narrow passages a D.C.-potential difference is applied.

12. A method according to claim 9, wherein the device is an assembly of electrically conductive metal sheets, which sheets are corrugated in a direction parallel to the desired path of electron flow, so that said corrugations cooperate to provide parallel channels or conduits for said electrons and said metal sheets at the input ends are coated with an insulating material.

13. A method according to claim 1, wherein the device includes a plurality of narrow parallel glass tubes of which the inner walls except for a part of the input openings are coated with a conductive layer and the insulating input ends stand in contact with the photocathode.

14. A method according to claim 6, wherein the insulating output opening ends of the device during the exposure stand in contact with the insulating target material.

15. A method according to claim 3, wherein the ionizable gas is a rare gas or a mixture of rare gases.

16. A method according to claim 15, wherein the gas medium contains xenon.

17. A method according to claim 1, with the modification that the means producing the electron discharge pattern and the device comprising a plurality of narrow passages are one and the same part of the electrostatic imaging device.

18. A method according to claim 17, wherein said means has photo-electron emitting properties when struck with X-rays.

19. A method according to claim 1, wherein the insulating charge receiving material is a transparent resin sheet which contains an electrically conductive rear side coating.

20. An imaging device for forming an electrostatic charge pattern wherein said device

contains in a gas-tightly closed envelope a cathode for generating an electron emission pattern and an ionizable gas and between said cathode and an insulating charge receiving target a device comprising a plurality of narrow passages for intercepting sideways spread of charged particles emitted by the cathode, the walls of the passages being not substantially secondary electron emissive, and the input openings of which are directed to or contact the cathode and the windowless output-openings of which are directed towards the insulating target which is demountable or removable from the envelope and said device.

21. An imaging device according to claim 20, wherein the envelope contains an ionizable gas with an atomic number at least equal to 36 and said gas is at atmospheric pressure or a pressure higher than atmospheric pressure.

22. An imaging device according to claim 20, wherein between a conductive backing of the cathode, which is a photocathode, a conductive backing applied on or contacting the insulating target material a DC-voltage source is connected with the negative pole to the conductive backing of the photocathode and with the positive pole to the conductive backing of the insulating target material.

23. An imaging device according to claim 22, wherein the said narrow passages of the device are electrically conductive but at the input openings are coated with an electrically insulating material that does not block the input-openings and said narrow passages are arranged in substantially parallel relationship to each other in the ionizable gas medium.

24. An imaging device according to claim 23, wherein between the conductive backing of the photocathode and the conductive part of the narrow passages a D.C.-potential difference is applied.

25. An imaging device according to claim 24, wherein the plus pole of a DC-voltage source is connected to the conductive part of said narrow passages and the negative pole to a conductive backing of the photocathode and the potential difference can be varied with a variable resistor.

26. An imaging device according to claim 22, wherein the narrow passages are built up by an assembly of electrically conductive metal sheets (lamellae), which sheets are corrugated in a direction parallel to the desired path of electron flow so that said corrugations cooperate to provide parallel channels or conduits for electrons and said metal sheets at the input openings are coated with an insulating material.

27. An imaging device according to claim 20, wherein the narrow passages are built up by a bundle of narrow tubes.

28. An imaging device according to claim 27, wherein the device includes a plurality of narrow parallel glass tubes of which the inner walls except for a part at the input openings are coated with a conductive layer and the insulating input ends stand in contact with a photocathode.

29. An imaging device according to claim 20, wherein the narrow passages have a diameter in the range of 10 to 200 microns.

30. An imaging device according to claim 21, wherein the ionizable gas is a rare gas or mixture of rare gases.

31. An imaging device according to claim 20, wherein the ratio of cross-section diameter to height of the individual narrow passages is at least 1:4.

32. An imaging device according to claim 20, wherein the distance between the output opening ends of the narrow passages and the insulating charge receiving target material is not larger than 1.5 mm.

33. An imaging device according to claim 22, with the modification that the photocathode and the solid state device comprising a plurality of narrow passages are one and the same part of the electrostatic imaging device.

34. An imaging device according to claim 33, wherein the photocathode has photo-electron emitting properties when struck with X-rays.

35. An imaging device according to claim 33, wherein the narrow passages are formed by a plurality of lamellae.

36. An imaging device according to claim 33, wherein the narrow passages are formed by a plurality of substantially parallel narrow tubes.

37. An imaging device according to claim 36, wherein the wall material of the tubes comprises an element or elements with an atomic number equal to or larger than 50.

38. An imaging device according to claim 33, wherein the height of the passages is in the range of 0.01 to 2 mm and the cross-section space is in the range of 10 to 200 microns.

39. An imaging device according to claim 33, wherein across the input openings of the passages an electrode layer or plate is present that has photo-electron-emissive properties.

40. An imaging device according to any of claims 20 to 39 including means for holding said insulating target material spaced from said windowless output openings.

41. An imaging device substantially as des-

cribed herein with reference to any of the accompanying drawings.

42. A method of recording a charged particle discharge pattern substantially as herein described with reference to the accompanying drawings.

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1455 011 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*

SHEET 1

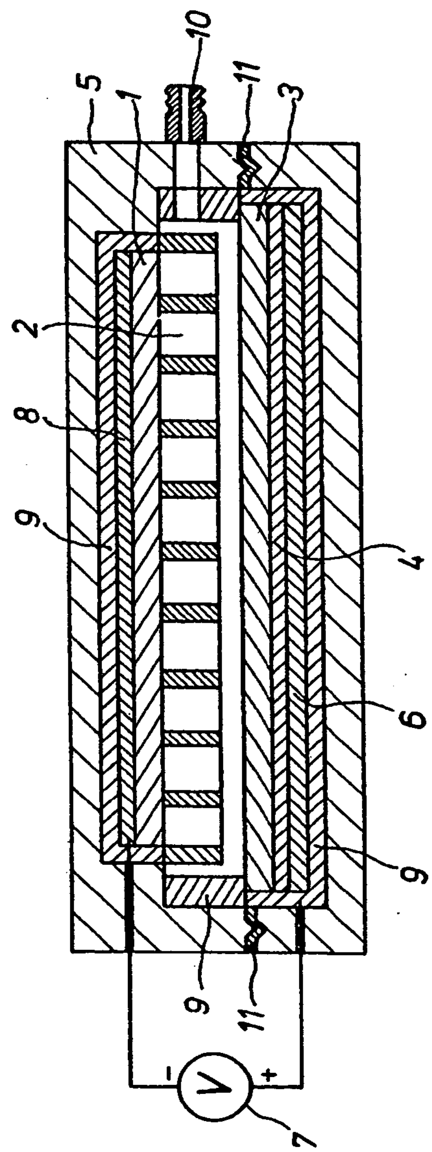

Fig.1

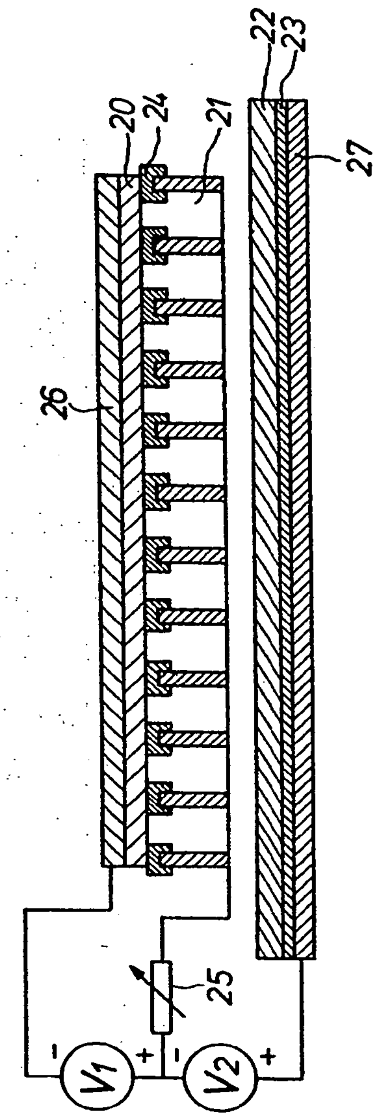

Fig.2

1 455 011 COMPLETE SPECIFICATION
4 SHEETS
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SHEET 3

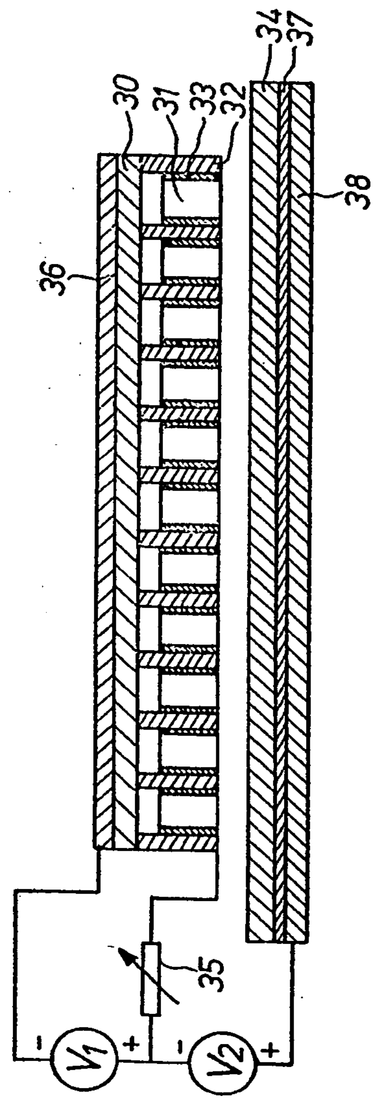

Fig.3

1 455 011
4 SHEETS

PLETE SPECIFICATION
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SHEET 4

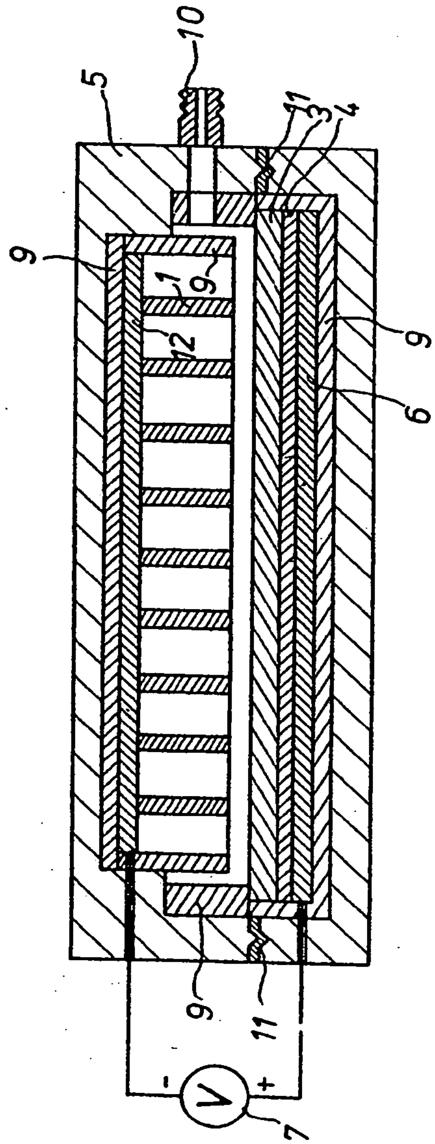

Fig.4